

LCLS Timing System (pattern design, evGUI, and high level)

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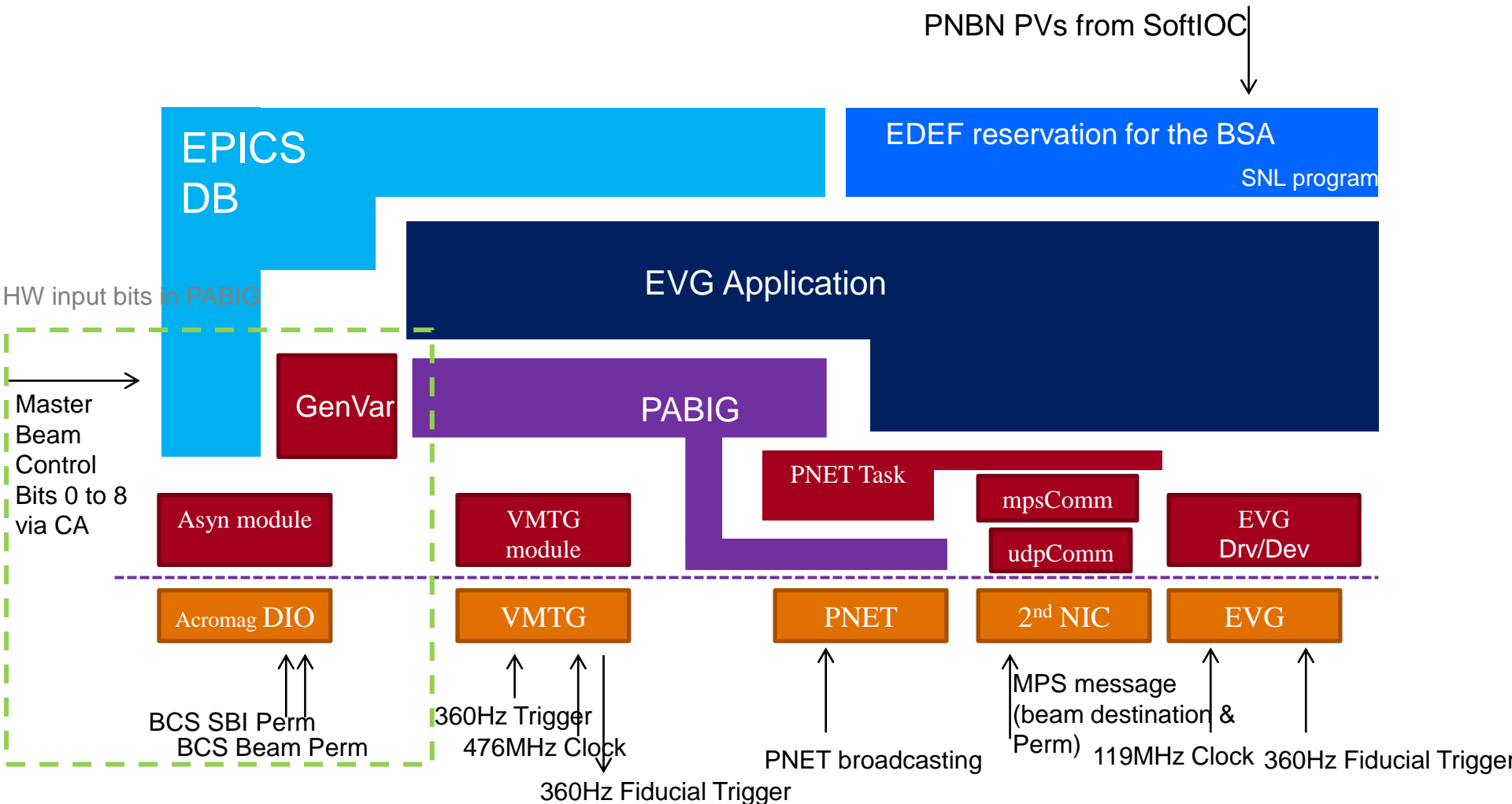
ICD Software, SLAC National Accelerator Laboratory

October 22, 2012

What's the problem?

- LCLS is a pulsed machine - timing system rate is 360 Hz
- LCLS beam rate is 120 Hz
- Need the ability to send e- from single source to multiple destinations, such as off-axis profile monitor, at different rates
- Need the ability to track an e- bunch as it traverses through the accelerator
- The Event Generator (EVG) needs to send out these timing patterns
- The event consumers need to listen for their specific timing pattern

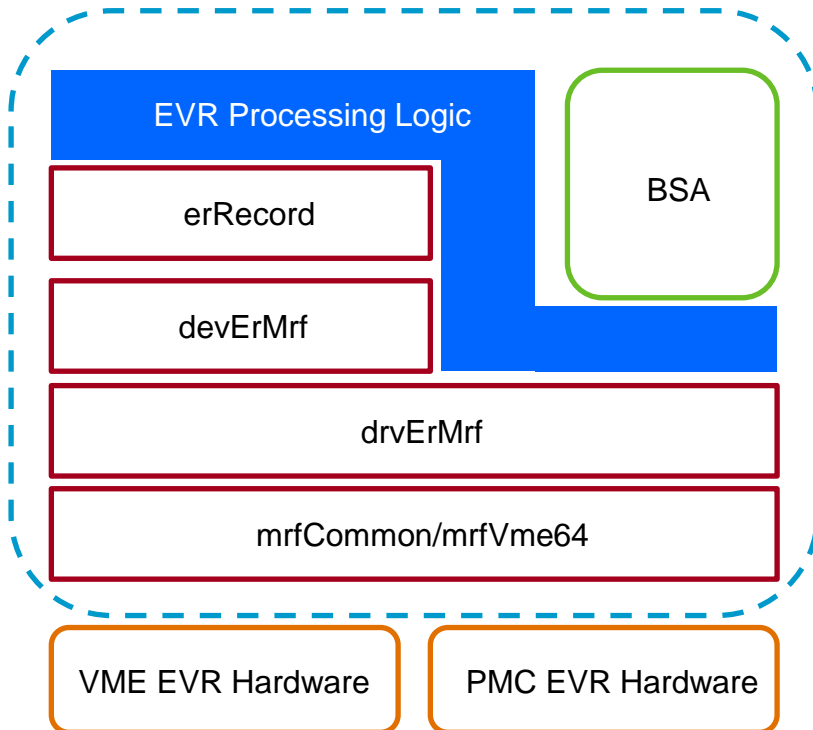
Software Stacks for the new EVG application and the PABIG



EVR Software Stacks/ Form factor & OS dependency

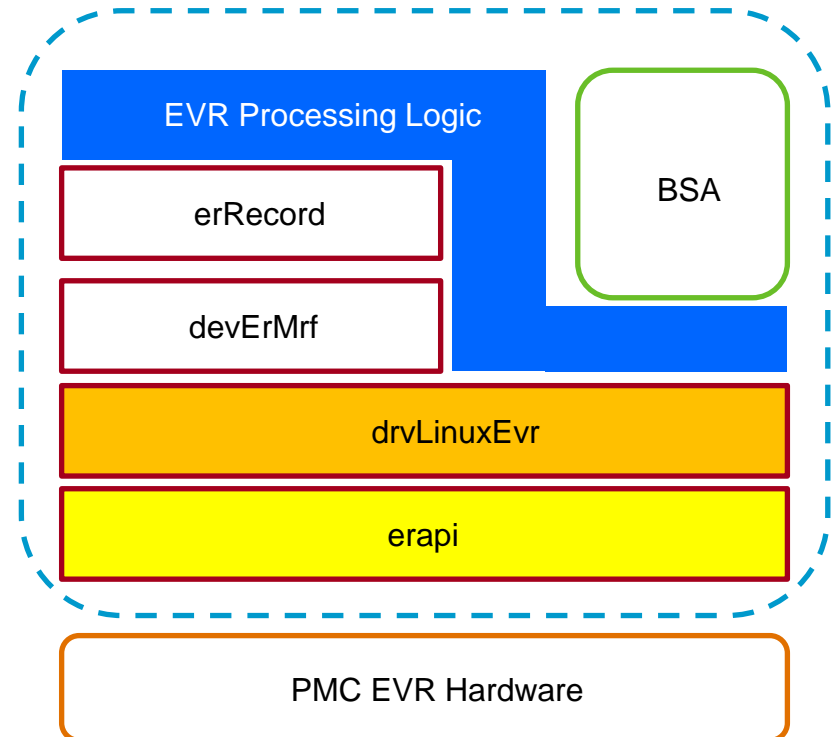
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Event Module for RTEMS/vxWorks



Works with old register map

Event Module for linux/linuxRT



Works with modular register map (new)

Beam Synchronous Acquisition (BSA)

- evGUI is used to program the Pattern Bit Generator (PABIG) to send the timing patterns
- Event Definitions (EDEFs) are used to listen to specific timing patterns
- Pattern Bit Names (PNBN) name specific bits in the timing pattern
- This entire system is called Beam Synchronous Acquisition (BSA)

How to use BSA

- Use the evGUI to set up the EVG
- Set up EVRs to listen to your pattern
- Collect your data from IOCs

Pattern Bit Names

evGUI evgui-R0-0-4

Define Modifiers Define Rate Groups Define Input Bits Define Beam Rates Define Patterns

Add New Modifier Clear Selected Modifier

Editable?	Modifier Name	Category	Bit Position	Bit Length	From MPG?
YES	YY		0	8	<input type="checkbox"/>
YES	beam_code (PP)		8	5	<input type="checkbox"/>
YES	MPG_IPLING		14	1	<input type="checkbox"/>
YES	MOD720RESYNC		15	1	<input type="checkbox"/>
YES	PULSIDRESYNC		16	4	<input type="checkbox"/>
YES	PSK_CONTROL	OTHER	20	12	<input type="checkbox"/>
YES	TS1	TIMESLOT	32	1	<input type="checkbox"/>
YES	TSLOT_U6		32	6	<input type="checkbox"/>
YES	TS2	TIMESLOT	33	1	<input type="checkbox"/>
YES	TS3	TIMESLOT	34	1	<input type="checkbox"/>
YES	TS4	TIMESLOT	35	1	<input type="checkbox"/>

Save to IOC & SCORE Load from SCORE

10/17 16:12:27 INFO Successfully loaded rates configuration.

Pattern Bit Names

evGUI evgui-R0-0-4

Define Modifiers Define Rate Groups Define Input Bits Define Beam Rates Define Patterns

Add New Modifier Clear Selected Modifier

Editable?	Modifier Name	Category	Bit Position	Bit Length	From MPG?
YES	SCAVINJ	OTHER	45	1	<input type="checkbox"/>
YES	SCREEN30	OTHER	43	1	<input type="checkbox"/>
YES	SDRSTOR_LER	OTHER	48	1	<input type="checkbox"/>
YES	SDRSTORE	OTHER	48	1	<input type="checkbox"/>
YES	shutter_perm	OTHER	55	1	<input type="checkbox"/>
YES	SIXTY_HERTZ	OTHER	72	1	<input type="checkbox"/>
YES	SLC_MTG_DISA	OTHER	96	1	<input type="checkbox"/>
YES	TCAV	OTHER	95	1	<input type="checkbox"/>
YES	TCAV3	OTHER	62	1	<input type="checkbox"/>
YES	TEN_HERTZ	OTHER	74	1	<input type="checkbox"/>
YES	THIRTY_HERTZ	OTHER	73	1	<input type="checkbox"/>

Save to IOC & SCORE Load from SCORE

10/17 16:12:27 INFO Successfully loaded rates configuration.

Pattern Bit Names

- Notice Beam Code are bits 8-12
- Notice TCAV is modifier bit 95

Rate Group

evGUI evgui-R0-0-4

Define Modifiers Define Rate Groups Define Input Bits Define Beam Rates Define Patterns

Put Checked Rate Groups to EVG Add New Rate Group Remove Selected Group & Rates

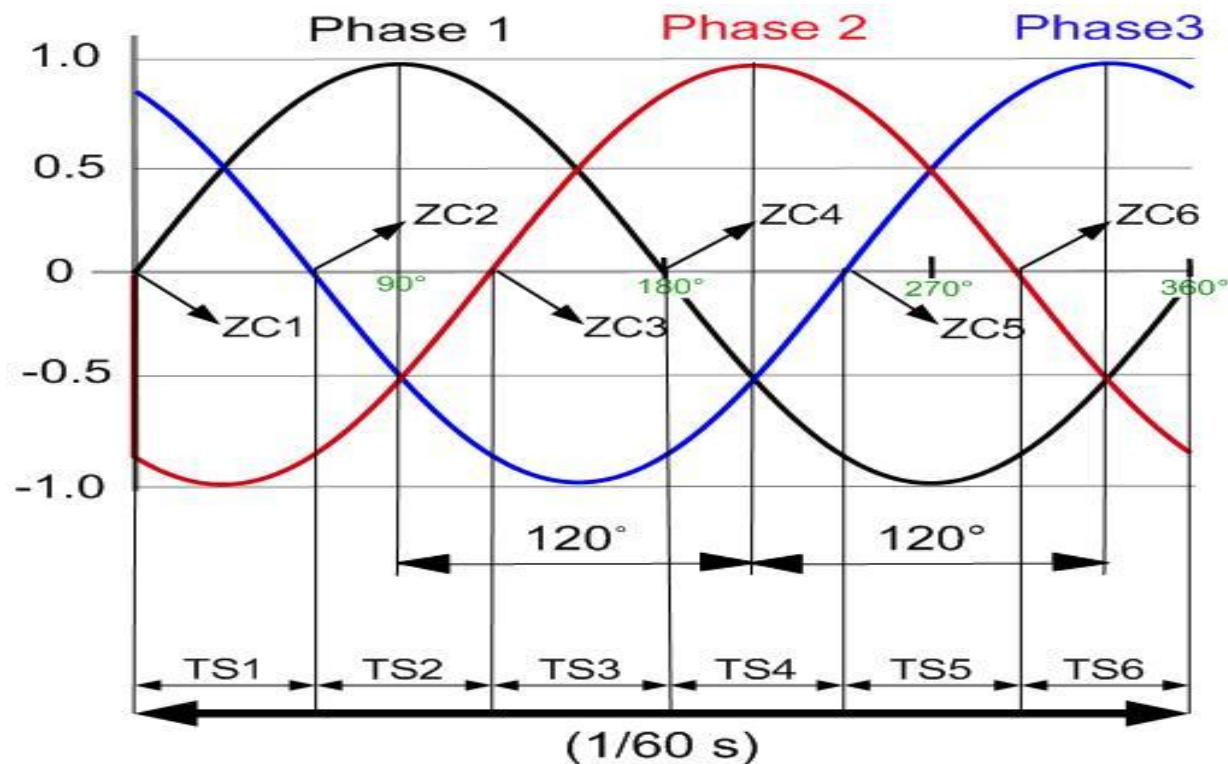
Put to EVG?	Rate Group ...	TS1	TS2	TS3	TS4	TS5	TS6
<input checked="" type="checkbox"/>	LCLS 120	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Save to IOC & SCORE Load from SCORE

10/17 16:12:27 INFO Successfully loaded rates configuration.

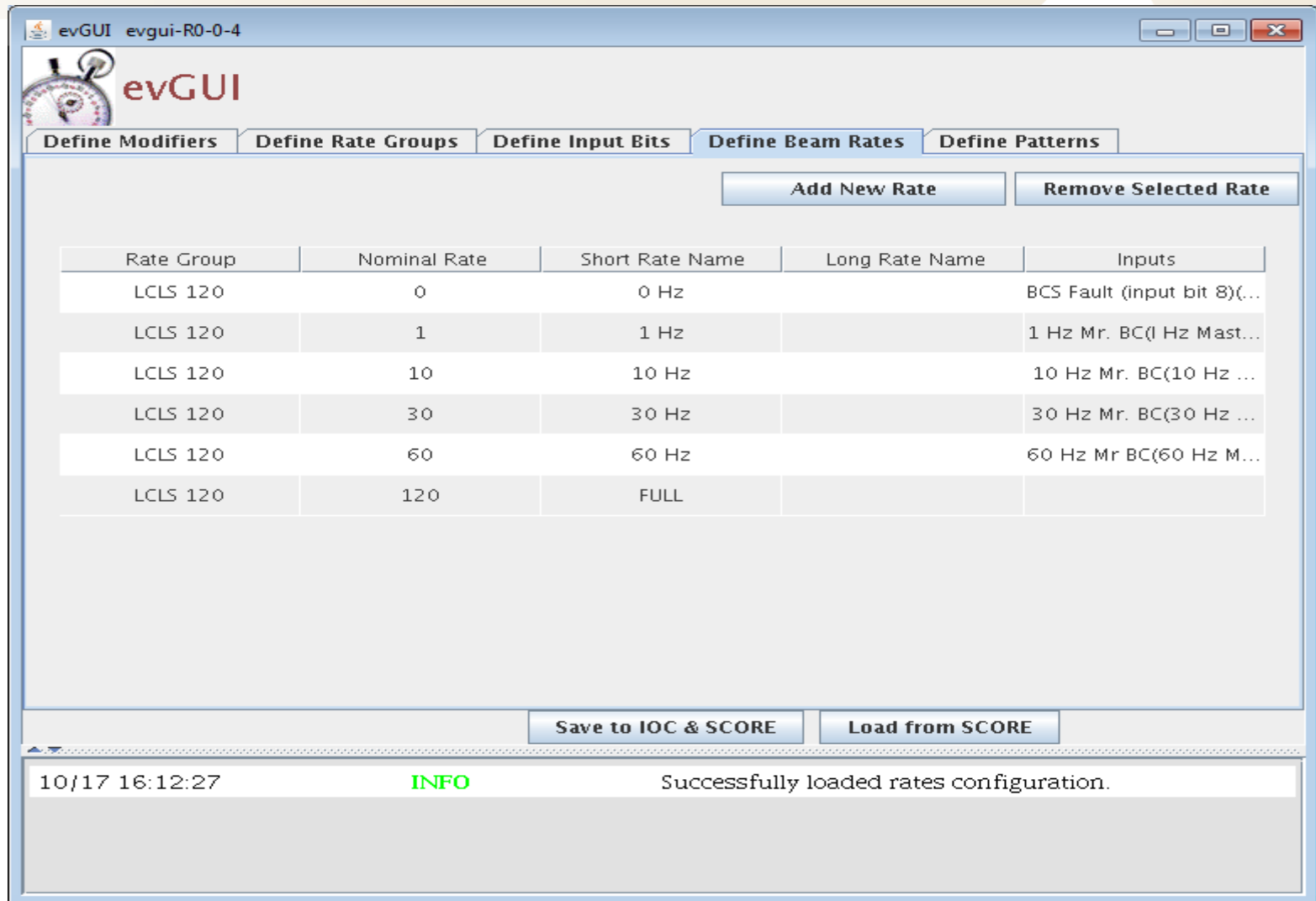
Rate Group

- Notice how LCLS is programmed to use time slots 1 & 4
- This leads to beam at 120 Hz for a 360 Hz timing system



ZC = Zero Crossing
TS = Time Slot

Beam Rates



evGUI evgui-R0-0-4

Define Modifiers Define Rate Groups Define Input Bits **Define Beam Rates** Define Patterns

Add New Rate Remove Selected Rate

Rate Group	Nominal Rate	Short Rate Name	Long Rate Name	Inputs
LCLS 120	0	0 Hz		BCS Fault (input bit 8)(...
LCLS 120	1	1 Hz		1 Hz Mr. BC(1 Hz Mast...
LCLS 120	10	10 Hz		10 Hz Mr. BC(10 Hz ...
LCLS 120	30	30 Hz		30 Hz Mr. BC(30 Hz ...
LCLS 120	60	60 Hz		60 Hz Mr BC(60 Hz M...
LCLS 120	120	FULL		

Save to IOC & SCORE Load from SCORE

10/17 16:12:27 INFO Successfully loaded rates configuration.

- Notice how LCLS experimenters can request a variety of beam rates
 - 0 Hz
 - 1 Hz
 - 10 Hz
 - 30 Hz
 - 60 Hz
 - 120 Hz
- Timing system always runs at 360 Hz

LCLS 10 Hz Pattern Definition

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evGUI evgui-R0-0-4

evGUI

HELP EXIT

Define Modifiers Define Rate Groups Define Input Bits Define Beam Rates Define Patterns

Rate Group **LCLS 120** # of seconds to display **0.2s**

Timeslot	Used?	Display Pattern?
TS1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
TS2	<input type="checkbox"/>	<input checked="" type="checkbox"/>
TS3	<input type="checkbox"/>	<input checked="" type="checkbox"/>
TS4	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
TS5	<input type="checkbox"/>	<input checked="" type="checkbox"/>
TS6	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Patterns for 10 Hz

Add Modifier Bit Remove Selected Modifier Bit

Modifier Bit	If	Frequency...	Offset (1/360 sec)	Value	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
beam_code (PP)		120	1	1	1	.	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.	.	1
pockcel_perm		10	4	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NO_GUN_PERM		120	1	1	1	.	.	1	.	.	1	.	.	1	.	.	1	.	.	1	.	.	1
NO_GUN_PERM		10	4	0	1	.	.	.	.	.	1	.	.	1	.	.	1	.	.	1	.	.	1
ONE_HERTZ		1	4	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TEN_HERTZ		10	4	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
THIRTY_HERTZ		30	4	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
SIXTY_HERTZ		60	1	1	1	1	1	1
TCAV	Mr. BC bit 6(TCAV0)	1	4	1	.	.	.	1

Save to IOC & SCORE Load from SCORE

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LCLS 10 Hz Pattern Definition

- Notice that TCAV bit comes out at 1 Hz on time slot 4 for 10 Hz pattern
- Master Beam Control is a hardware box used to enable the TCAV bit in the timing pattern
- Pattern repeats every 2 seconds

LCLS Master Beam Control

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How to use BSA

- Use the evGUI to set up the EVG
- Set up EVRs to listen to your pattern
- Collect your data from IOCs

Reserving an Event Definition (EDEF)

- Once the timing pattern is set up, how do I use it?
- Reserve an Event Definition
 - Allows user to listen to specific timing pattern
 - Allocates a set of PV names for user's specific needs
 - PVs exist for devices that care about beam crossing time (BSA), such as Beam Position Monitors (BPMS)

Reserving an Event Definition (EDEF)

SYS0 EDEFs

SYS0 Event Definitions (EDEFs)

Production

of Available EDEFs: 5

EDEF Reserve: **EXIT**

	App Name	User		Last Active Time	Last Reserved Time
1			OFF	10/17/12 14:52:32	10/17/12 14:52:31
2	Feedback TS1 & ~30Hz	Client	ON	09/25/12 00:31:16	09/23/12 18:01:26
3	Fast Event Logger 98	Client	ON	10/17/12 11:03:03	09/23/12 18:01:32
4					17/12 14:55:27
5	GDET Averager				11/12 21:20:00
6					16/12 12:07:15
7			OFF	10/17/12 16:22:54	10/17/12 16:18:04
8	zelazny	Client	OFF	10/17/12 17:05:30	10/17/12 17:04:50
9			OFF	10/17/12 13:21:02	10/17/12 12:52:23
10	WIRESKAN_020154_411	Client	OFF	10/17/12 02:06:30	10/17/12 02:01:54
11	OD-R0-0-62-physics-lcls-opi01-18171	Client	ON	10/04/12 23:26:11	10/04/12 20:55:27
12	tcav_feedback	Client	ON	09/23/12 18:01:12	09/23/12 18:01:10
13	Feedback TS4 & 30Hz	Client	ON	09/25/12 00:31:06	09/23/12 18:01:15
14	Feedback TS1 & 30Hz	Client	ON	09/25/12 00:31:09	09/23/12 18:01:19
15	Feedback TS4 & ~30Hz	Client	ON	09/25/12 00:31:12	09/23/12 18:01:22
1H	1HZ	SYS	ON	09/20/12 17:16:07	09/20/12 17:16:07
TH	10HZ	SYS	ON	09/20/12 17:16:07	09/20/12 17:16:07
BR	FULL	SYS	ON	09/20/12 17:16:07	09/20/12 17:16:07
F1	bunch-charge-feedback	SYS	ON	10/17/12 17:08:25	09/20/12 17:16:07
F2	FBCK2	SYS	ON	09/20/12 17:16:07	09/20/12 17:16:07

LCLS

EVG assigned slot 8 for my use

Look for specific bits in the timing pattern

EDEF:SYS0:8 Event Definition

SYS0 Event Definition 8
Production EXIT

Name: OFF Last Active Time: 10/17/12 17:05:30
User: ON Last Reserved Time: 10/17/12 17:04:50
Client:

Timing Pattern Masks Mask Setup
EDEF Inclusion Mask
TCAV pockcel_perm

EDEF Exclusion Mask
TS2 TS3 TS5 TS6

Beam Code

Measurement Parameters
to Average per Measurement: # Measurements:
0 = Abort. -1 = Forever
Severity Level for Invalid Data: NONE MINOR MAJOR INVALID
Total to Acquire: Reset DATA
Total Acquired so far: Release EDEF

LCLS

Define mask here

Specify number of samples

Selecting Specific Bits for EDEF

EDEF:SYS0:8 Exclusion and Inclusion Mask Setup

SYS0 Event Definition 8 Exclusion and Inclusion Mask Setup

Production EXIT

Name	zelazny	User	Client
<input type="checkbox"/> ASSET	<input type="checkbox"/> EXTB_LER0	<input type="checkbox"/> GUNB_LER1	<input type="checkbox"/> RATE_01HZ
<input type="checkbox"/> Asset_inj	<input type="checkbox"/> EXTB_LER1	<input type="checkbox"/> HERINJNDR	<input type="checkbox"/> RATE_05HZ
<input type="checkbox"/> BCSFAULT	<input type="checkbox"/> FBCK_FB3PHAS	<input type="checkbox"/> HER_BEAMABRT	<input type="checkbox"/> RATE_10HZ
<input type="checkbox"/> BPMX1INJECT	<input type="checkbox"/> FBCK_HER	<input type="checkbox"/> INJT_HER	<input type="checkbox"/> RATE_30HZ
<input type="checkbox"/> BPMX1LINAC	<input type="checkbox"/> FBFASTLIN	<input type="checkbox"/> INJT_LER	<input type="checkbox"/> RATE_HALFHZ
<input type="checkbox"/> BYP_K_HER	<input type="checkbox"/> FBSCAVINJNDR	<input type="checkbox"/> KICKER_LI25	<input type="checkbox"/> SBDARCN
<input type="checkbox"/> BYP_K_LER	<input type="checkbox"/> FBSLOWINJ	<input type="checkbox"/> KICKER_LTU	<input type="checkbox"/> SBDARCN_AUX
<input type="checkbox"/> Calibration	<input type="checkbox"/> FBSLOWINJ2	<input type="checkbox"/> LCLS_BEAM	<input type="checkbox"/> SBDARCS
<input type="checkbox"/> DUMP_2_9	<input type="checkbox"/> FBSLOWLIN	<input type="checkbox"/> LER_BEAMABRT	<input type="checkbox"/> SBDARCS_AUX
<input type="checkbox"/> DUMP_2_9_AUX	<input type="checkbox"/> FB_HERINJNDR	<input type="checkbox"/> MAKE_EP_LER	<input type="checkbox"/> SCAVINJ
<input type="checkbox"/> DUMP_BAS1	<input type="checkbox"/> FB_PEPPOSI	<input type="checkbox"/> MPS_BYKIK	<input type="checkbox"/> SCREEN30
<input type="checkbox"/> DUMP_BYP_HER	<input type="checkbox"/> FB_SCAV	<input type="checkbox"/> MPS_LHTRSHUT	<input type="checkbox"/> SDRSTORE
<input type="checkbox"/> DUMP_BYP_LER	<input type="checkbox"/> FFTB_ext	<input type="checkbox"/> MPS_MECHSHUT	<input type="checkbox"/> SDRSTOR_LER
<input type="checkbox"/> DUMP_K02	<input type="checkbox"/> FFTB_inj	<input type="checkbox"/> MPS_POCKCELL	<input type="checkbox"/> SIXTY_HERTZ
<input type="checkbox"/> DUMP_K02_AUX	<input type="checkbox"/> FIDSH_HLR0	<input type="checkbox"/> NO_EXT_ELEC	<input type="checkbox"/> SLC_MTG_DISA
<input type="checkbox"/> E144_LC	<input type="checkbox"/> FIDSH_HLR1	<input type="checkbox"/> NO_EXT_E_AUX	<input type="checkbox"/> TCAV
<input type="checkbox"/> E154witness	<input type="checkbox"/> FIDSH_HLR2	<input type="checkbox"/> NO_EXT_POSI	<input type="checkbox"/> TCAV3
<input type="checkbox"/> ESA_PED	<input type="checkbox"/> FIDSH_HLR3	<input type="checkbox"/> NO_EXT_P_AUX	<input type="checkbox"/> TEN_HERTZ
<input type="checkbox"/> EVG_BURST	<input type="checkbox"/> FIVE_HERTZ	<input type="checkbox"/> NO_GUN_PERM	<input type="checkbox"/> THIRTY_HERTZ
<input type="checkbox"/> EVG_SPARE2	<input type="checkbox"/> FLIP	<input type="checkbox"/> NO_SCAV_PERM	<input type="checkbox"/> TS1
<input type="checkbox"/> EVG_SPARE5	<input type="checkbox"/> GUNA_HER	<input type="checkbox"/> ONE_HERTZ	<input type="checkbox"/> TS2
<input type="checkbox"/> EXTA_HER	<input type="checkbox"/> GUNA_HER0	<input type="checkbox"/> PHAS_DITHR	<input type="checkbox"/> TS3
<input type="checkbox"/> EXTA_HER0	<input type="checkbox"/> GUNA_HER1	<input type="checkbox"/> PNET_SEQCHK	<input type="checkbox"/> TS4
<input type="checkbox"/> EXTA_HER1	<input type="checkbox"/> GUNB_LER	<input type="checkbox"/> PROF_DIAG	<input type="checkbox"/> TS5
<input type="checkbox"/> EXTB_LER	<input type="checkbox"/> GUNB_LER0	<input type="checkbox"/> PULSID_ZERO	<input type="checkbox"/> TS6
<input type="checkbox"/> TSLOT_U6			<input type="checkbox"/> pockcel_perm
<input type="checkbox"/> shutter_perm			

Inclusion Mask TCAV pockcel_perm

Exclusion Mask TS2 TS3 TS5 TS6

	Modifier 6	Modifier 5	Modifier 4	Modifier 3	Modifier 2
Inclusion Mask	0x0	0x0	0x0	0x80080000	0x0
Exclusion Mask	0x0	0x0	0x0	0x0	0x36

LCLS

Start your data collection

EDEF:SYS0:8 Event Definition

SYS0 Event Definition 8
Production EXIT

Name: OFF Last Active Time: 10/17/12 17:05:00

User: ON Last Reserved Time: 10/17/12 17:04:50

Timing Pattern Masks Mask Setup

EDEF Inclusion Mask

TCAV pockcel_perm

EDEF Exclusion Mask

TS2 TS3 TS5 TS6

Beam Code

Measurement Parameters

to Average per Measurement: # Measurements:
0 = Abort. -1 = Forever

Severity Level for Invalid Data

NONE MINOR MAJOR INVALID

Total to Acquire: Reset DATA

Total Acquired so far: Release EDEF

LCLS

Start Collecting Data

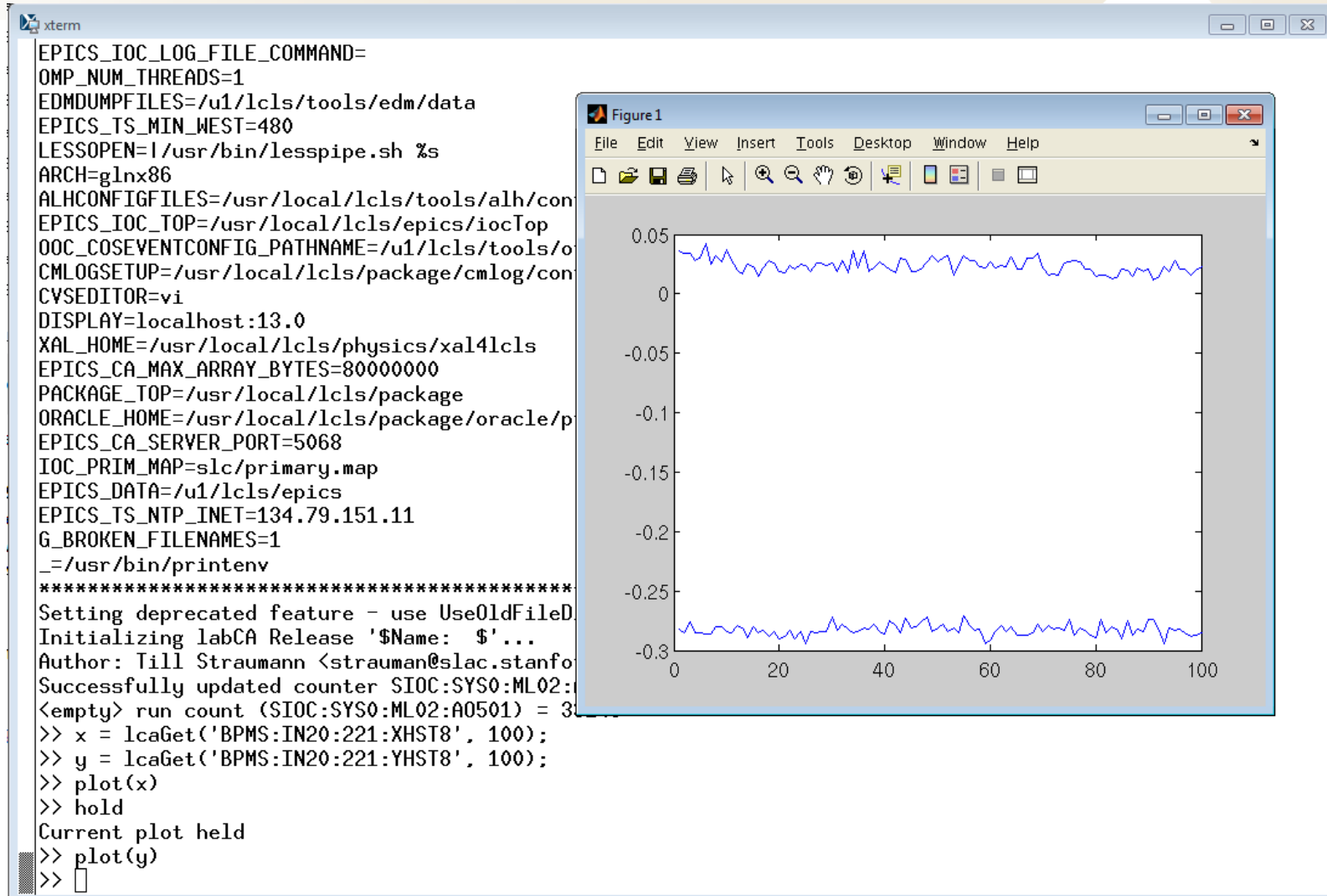
Setting up Event Definition

- Setup Timing Bits
- Notice TCAV bit is **included** – required by data acquisition software
- Notice # Measurements is set to 100
- Press **ON**
- Wait for data acquisition to complete
- Data gets buffered on IOC and retrieved over channel access

How to use BSA

- Use the evGUI to set up the EVG
- Set up EVRs to listen to your pattern
- Collect your data from IOCs

Getting Data from IOCs



Getting Data from the IOCs

- Notice how PV names have event definition number, **8**, encoded into the PV name
- Data is buffered on the IOC and can be retrieved over channel access. In our example our application is written in MATLAB and data is retrieved using Lab Channel Access (lca)
- Data across multiple IOCs listen to the same exact 100 pulses to
 - track single pulses traversing down the accelerator
 - perform beam jitter studies
- Entire procedure can be done in a MATLAB script
- LCLS has 877 signals that respond to BSA requests

Thank You!